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# RWATER World

## AMERICAN EEL

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# UNDERWATER World



## AMERICAN EEL

Canada

# The American Eel

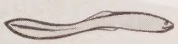
To many people, the eel is regarded with distaste, as a slimy, snake-like creature. Those who have enjoyed the sweet, white flesh, whether jellied, smoked or in a stew, know otherwise. Curiosity about eels, however, is widespread.

For centuries, speculation and myth have surrounded the life of the eel. From the 4th century B.C., when Aristotle provided the first recorded observations on the life of the eel, to the beginning of the 20th century, the location of the eels' spawning grounds and their movements at sea remained a mystery. While this mystery still exists, in 1922, the Danish oceanographer Johannes Schmidt reported the discovery of the eels' spawning grounds in the Sargasso Sea in the southwestern part of the North Atlantic Ocean. Schmidt also traced the migration routes of larval eels. It is now known that two species of eels inhabit the North Atlantic region. The American eel, *Anguilla rostrata,* while genetically distinct from the European eel, *Anguilla anguilla,* differs physically only slightly, having fewer vertebrae, and a larval stage of shorter duration.

## Description

The American eel is elongate and serpentine, with a single continuous dorsal fin extending posteriorly from a point about one third of the body length behind the head and around to the vent. Immature adult eels (yellow eels) may range in colour from yellowish to greenish or olive-brown, with the backs darker than the belly. Sexually maturing eels (silver eels) acquire a metallic sheen, bronze or black on the back and silvery below during their seaward reproductive migration. Eels can also alter their coloration in response to changes in illumination and background. The skin is thick and tough and may secrete copious amounts of slimy mucous, which acts as a protective cover. Unlike the well-developed scales of most other fishes, eel scales are rudimentary and embedded deeply within the skin. The scales develop only after the eel has spent about three years in freshwater.

American eels may occasionally be confused with the lamprey, sometimes called the lamprey eel. The lamprey, however, differs notably from the eel in having a prominent sucking disc filled with large, hooked teeth, several gill openings and no pectoral fins.



## Distribution

American eels occur in the estuaries and coastal freshwaters of North America. They can be found from their northern limit in the Hamilton Inlet-Lake Melville Estuary of Labrador, south from Newfoundland and the Gulf of St. Lawrence along the Atlantic coast of Canada and the United States

to the Gulf of Mexico, Panama and the West Indies. The American Eel also extends into the Great Lakes and up the Mississippi River. The Welland Canal is believed to be the point of access for eels to Lake Erie, Huron and Superior although they are uncommon. Small populations exist in southwest Greenland and eels have occasionally been found off the northern coast of South America.

## Life History

Eels are classed as catadromous fishes, which means that on attaining sexual maturity, adult eels migrate downstream to the sea where ultimately they spawn. Sexual maturation in eels seems more related to size than to age. Size at maturation varies geographically and according to sex, with male eels typically smaller than females. In addition to the enlargement and maturation of the sexual organs and changes in coloration of the skin, there is an accumulation of fat that provides energy during the marine phase of migration because feeding activity soon ceases and the gut degenerates. Additional changes adapt the body for its transition to the marine environment. Like other fishes that can move between fresh and salt water, the gill surfaces, the gut and the kidneys play important roles in regulating water and electrolyte balances in the body.

The spawning migration occurs between August and December. Downstream movement is most active at night and during the first few hours after sunset. Peak migration activity usually occurs during September and October during the last quarter of the moon and is enhanced by dark, stormy nights and rising water levels. Yellow eels may also be found migrating seaward in the autumn but they are believed to be moving to overwintering sites within the river or estuary. A few eels have been captured offshore along the continental shelf but the migratory routes and behaviour of silver eels at sea are unknown. From the northern areas of their geographical distributions, silver eels may migrate sooner and in a more immature state than from southern areas, thus permitting them to reach the spawning grounds at similar times and in similar reproductive condition. American eels spawn in the western part of the Sargasso Sea, with peak spawning occurring between February and April. Larger females spawn more eggs than do smaller females. Egg numbers have been estimated to range from about two million for a 45 cm long female to about twenty million for a 113 cm long female. No mature adults have ever been caught in the Sargasso Sea and their spawning behavior is unknown. It is presumed that the adults die after spawning. After hatching, most of the transparent, willow-leaf-shaped larvae (termed a leptocephalus) drift northward with the Gulf Stream, perhaps assisted by swimming activity, until

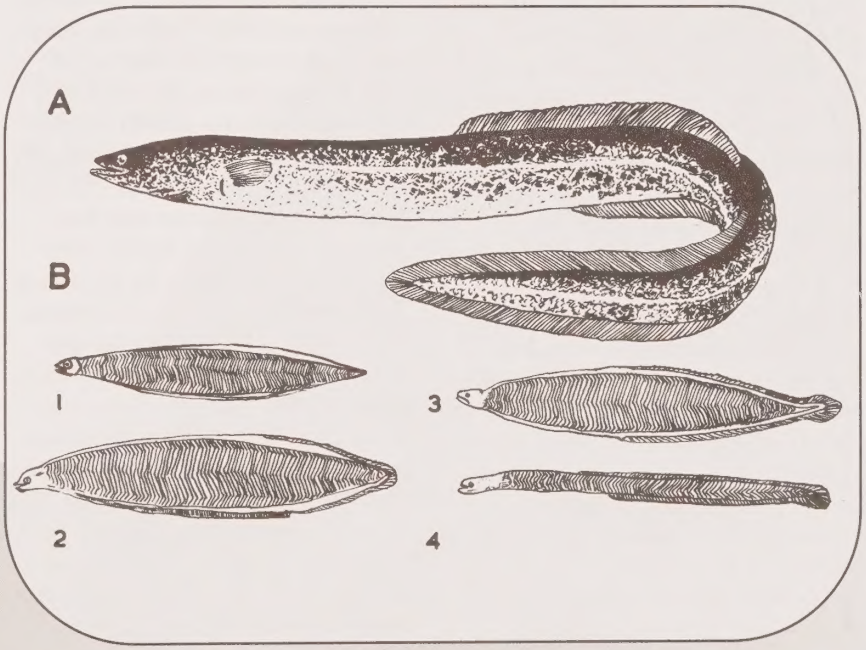
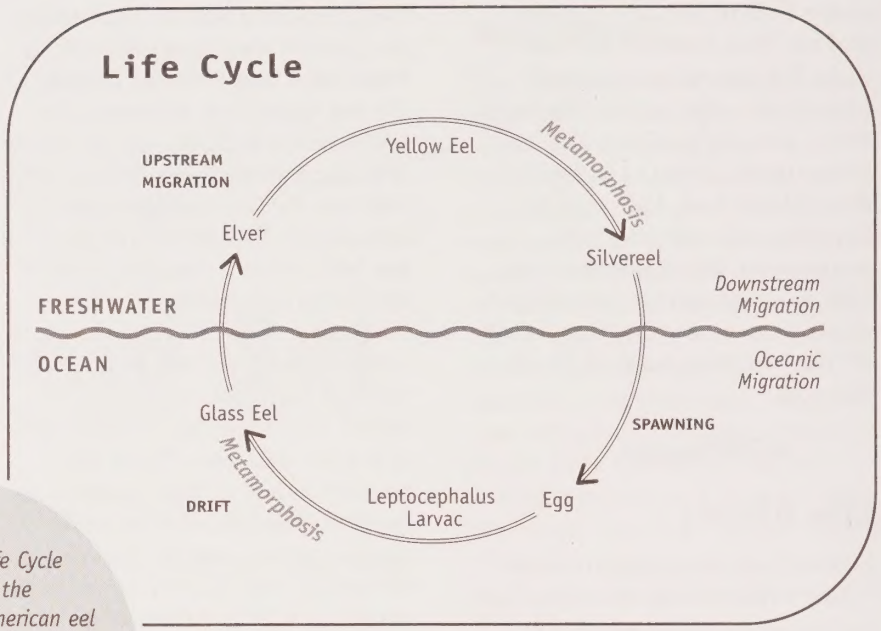



*Fig. 1 Drawings of (A) yellow eel and (B) leptocephali (drawn from Bigelow and Schroeder, 1953). 1. Leptocephalus (49mm); 2. Leptocephalus (55mm); 3. Leptocephalus (58mm); 4. Transformation stage (61 mm).*




*Life Cycle of the American eel*

they are eventually distributed along the North American coast. A year or more may be taken to reach Canadian waters. Over the continental shelf, the larvae undergo metamorphosis that involves a change to typical eel shape. The glass eel, as it is now termed because of its transparent form, begins to actively move towards shore. By the time it reaches the estuaries of coastal streams it has become more or less pigmented and is now termed an elver. Elvers are a small version of the adult eel. Elvers may range in size from 50 to 70 mm or more when they enter streams, often in large numbers, where water temperatures reach 6°to 8°C. The time of arrival varies geographically, from early May through June along the Atlantic coast of Nova Scotia to late June and July along the north shore of the Gulf of St. Lawrence. Most elver runs occur in several waves over a period of several weeks but small numbers of elvers may continue arriving over a longer period. Peak arrival may occur during spring tides at night. There is no evidence that elvers home to any particular stream and good reason to believe that they do not. Thus, because eel larvae are passively carried along the coast of North America by prevailing currents and glass eels display limited locomotory abilities, it is unlikely that an elver would find and enter the river from which its parents came. It is also unlikely that both parents would have come from the same river. Elvers may penetrate rivers for many miles inland, depending upon the gradient of the river and the obstructions encountered, but a proportion remains in estuarine and coastal areas. Upstream movements of young eels may occur over many years as they seek less crowded or better quality habitat and replace eels that have sexually matured and left the river. Elvers take about four years and have become young eels by the time they reach the upper St. Lawrence River. Eels may remain in freshwater from 5 to 15 years or longer (eels more than 30 years old have been reported) depending upon their growth rate, which depends in turn upon the feeding and environmental conditions encountered. Large female eels may exceed 1,000 mm in length and weigh over 2 kg, but males seldom exceed 400 mm in length. An abundance of small, yellow eels often dominates the lower reaches of rivers and estuaries with fewer, larger and mostly female eels predominant in the upper reaches.

The determination of sex may be influenced environmentally with higher population densities resulting in a high proportion of males. In larger rivers, most eels become female while in small streams the proportion of males may be high particularly if the stream has relatively poor habitat. For example, only females are found in the St. Lawrence River while in the Saint John River, NB, 97% of sexually identifiable eels were female. In the small, acid, and poorly productive East River, Chester, on the Atlantic coast of Nova Scotia, about 80% of the silver eels are male.

Eels apparently have relatively small home ranges within which they forage. Changes of habitat tend to occur only during transitional periods such as the spring and autumn. The major movement occurs in autumn when silver eels migrate to sea. Some yellow eels travel to overwintering sites if their summer habitat is

unsuitable. Yellow eels that moved downstream to the estuary in the spring now return to the river, even to the same area within the river. Eels transported up to 100 km away from their home waters have successfully found their way back. How this is done is not fully understood but may result from the eels' ability to orient to the earth's magnetic field and to detect river odours.

Yellow eels are generally active at night, retiring to burrows in muddy bottoms or to other cover during daylight. Bright moonlight will inhibit their nighttime activity. Temperature influences the degree of seasonal activity and eels become noticeably less active when the water temperature drops below 11 °C in autumn. During winter, eels hibernate in the bottom mud.

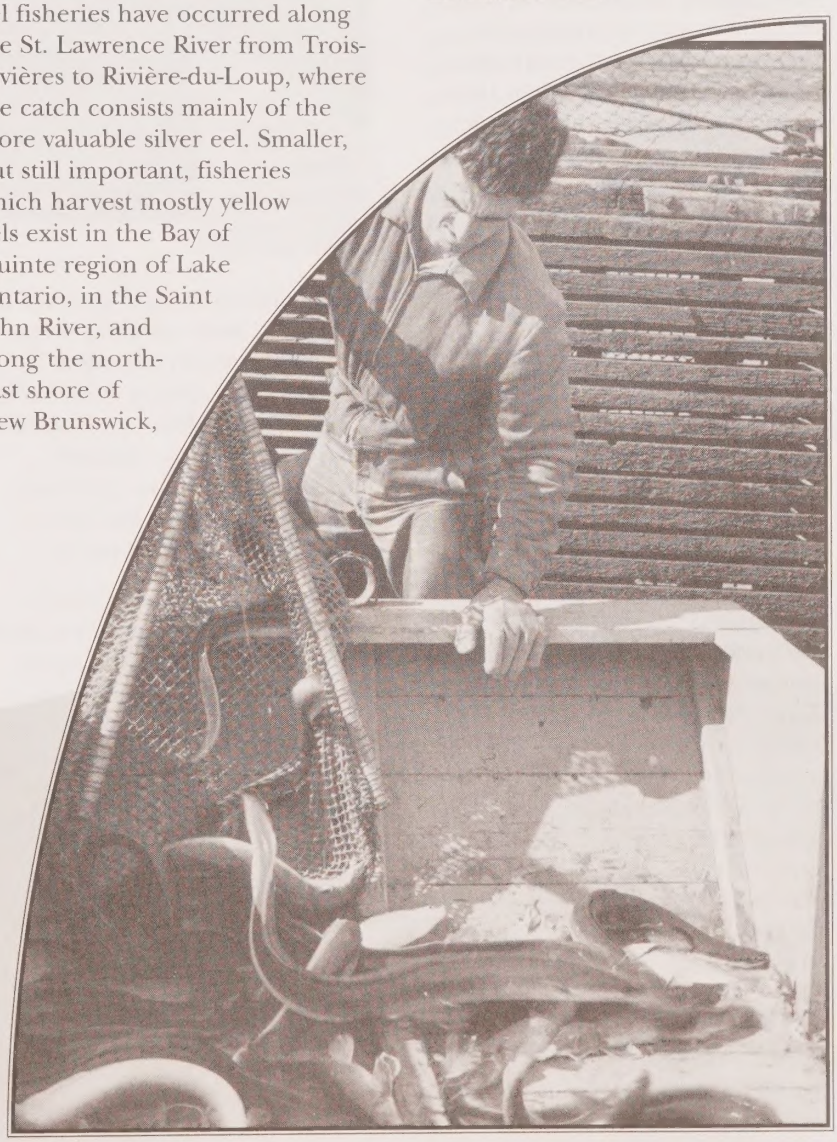
Eels are voracious carnivores and consume a variety of fishes and invertebrates such as insects, crayfish, snails and worms. An acute sense of smell assists in the location of food, which is preferred fresh rather than decayed. Eels will, however, feed on recently dead fish caught in nets. Young salmon and trout may be included amongst the small fish preyed upon but since eels tend to avoid the cool, rapid flowing waters favored by the salmonids, they are not likely to be a significant threat. One study concluded that about 10 per cent of the eels examined had consumed fish while 90 per cent contained mostly insects. Eels may, of course, fall prey to other predators. Small eels are particularly vulnerable.

## Fishery

Commercial fisheries for eels have existed in Canada since colonial times. During that era, eel fisheries were pursued most actively by the French of Quebec and Acadian New Brunswick, who pickled quantities of eels for home consumption and export. One commentator of the mid-1800s observed that "the eel, although in reality an excellent foodfish, is not much esteemed in Nova Scotia".

Historically, the most successful eel fisheries have occurred along the St. Lawrence River from Trois-Rivières to Rivière-du-Loup, where the catch consists mainly of the more valuable silver eel. Smaller, but still important, fisheries which harvest mostly yellow eels exist in the Bay of Quinte region of Lake Ontario, in the Saint John River, and along the north-east shore of New Brunswick, on Prince Edward Island and along the southern coast of mainland Nova Scotia, and on Cape Breton Island. Newfoundland has a minor fishery.

Few fish are caught in so many ways as is the eel. Local preferences and environmental conditions govern the choice of method used. Ontario fishermen use baited setlines, hoopnets, trapnets, and even electro-fishing boats. Setlines take about 65 per cent of the catch and are popular in inshore areas



*Capturing eels in Quebec*

*Fishing for eels with hoop nets*

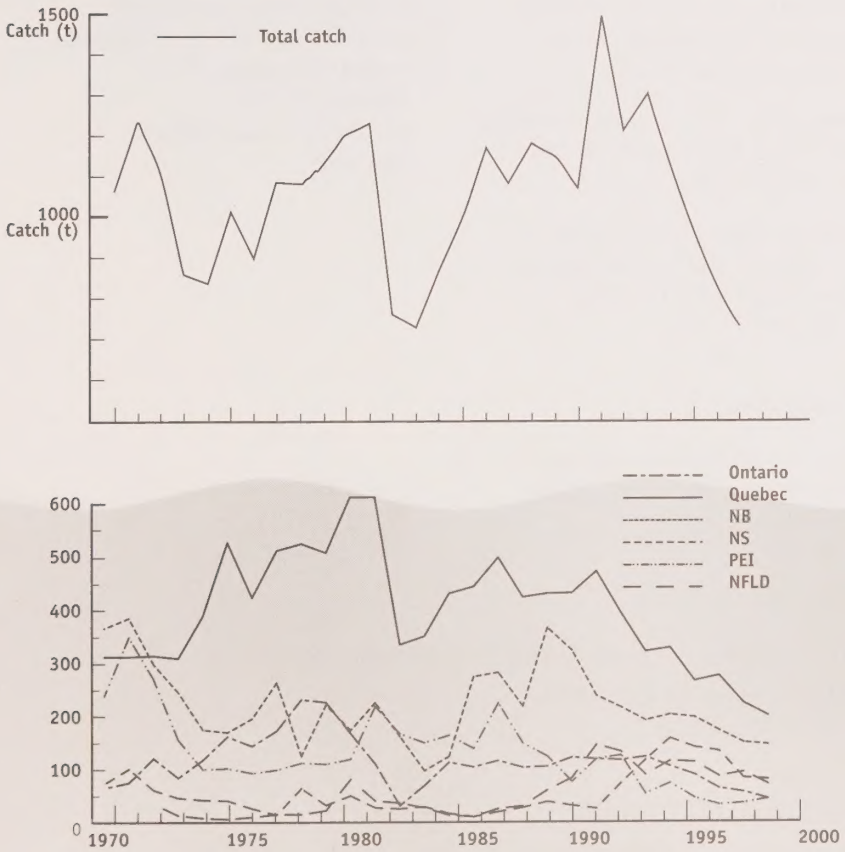
because one man can operate them and they are inexpensive. They consist of many baited hooks, typically 200 to 250, attached by short leaders to a long line held on the bottom by weights at each end. Hoop nets use one or two netting leaders attached to a body formed of netting-covered hoops within which are a series of cones of netting with small openings at the apex. They are set in shallow waters, often over a muddy bottom. Single leader nets are usually set at right angles to the shore; while double leader or wing nets set in lakes may be arranged in chains or set facing the current in streams. Trap nets are larger than hoop nets and consist of a leader running to a rectangular netting box or pound which is held in place by stakes and guy ropes. Species other than eels are often caught in these nets. The inland fisheries of Quebec use trapnets, while the estuarine fishery of the St. Lawrence River uses weirs. Weirs typically consist of V-shaped walls, opening upstream, which block off a portion of the river forcing the water flow through a trap at the apex of the "V". A good flow of water is necessary and weirs are often situated to take advantage of natural features in the stream. Maritime fishermen use baited pots, hoopnets and, along the south shore of Nova Scotia, weirs. Eel pots are often homemade, of variable design, and commonly made of wood lath or wire mesh. A bait is used to attract the eel into a wide, rapidly narrowing funnel at one end of the pot which empties into a chamber from which the eel has difficulty escaping. Baits must be fresh because eels will ignore old baits. During the winter, Maritime fishermen, using multipronged eel spears, also catch small quantities of eels for local consumption. Other fish species are often caught in fyke or trap nets. Such bycatches can often be released alive when nets are regularly checked but, in some provinces, devices to minimize bycatch are required or are being tested.

Annual eel catches vary widely among provinces and have ranged between about 750-1,500 metric tonnes (t) since 1970. Catches in Ontario, Quebec, Prince Edward Island and rivers of New Brunswick and Nova Scotia draining into the Gulf of St. Lawrence have declined since the mid 1980s. The cause(s) of this decline in eel abundance is uncertain but may result from a decreased abundance of elvers entering the Gulf of St. Lawrence due to adverse oceanic conditions. The decline in Lake Ontario eel catch is linked to the long-term decline in the number of young eels being passed upstream at hydroelectric dams on the upper St. Lawrence River. This decline may, in turn, be linked to the apparent decline in elver abundance in the lower St. Lawrence River. Habitat loss and obstruction to eel passage upstream, by hydroelectric dams for example, and mortality of eels passing downstream through turbines can also contribute to reduced eel abundance. Excessive fishing pressure is another potential concern when local catches decline.

In 1997, the total Canadian harvest was about 700 t, worth about 6.3 million dollars. A substantial part of this value was contributed by the higher prices for elvers from the fishery conducted in the Atlantic coastal areas of Nova Scotia and New Brunswick. The elver fishery began in 1989 in response to demand in Asia for elvers for aquaculture. Recent low

prices for elvers have resulted in a collapse of the elver fishery but it may rebound with an increase in elver prices.

Changing market conditions and variations in eel abundance influences landings. In Maine, fluctuations in the quantity of eels harvested have been related to water temperatures in the Gulf of Maine 10 years earlier, with high landings resulting from lower sea temperatures. Most of the harvest is exported to Western Europe, although regional domestic markets catering to several ethnic groups are important. Live eels are preferred to frozen eels for the export market; silver eels are preferred to yellow eels because of their larger size and higher fat content which results in a better smoked product. The demand for live eels and their high value permit the use of airfreight to ship them to export markets. At their destination, local processors prepare the eels according to their requirements. Large quantities are smoked; others are jellied or marinated. Tanned eel skins have also been used in high quality leather products.




*Reported catches (t) of American eels, by province.*

## Management

Modern fisheries are regulated by management plans based on the results of regular scientific "assessments" of each fish stock or group of related stocks. Unfortunately, few eels stocks receive the attention necessary for effective management and the large body of data required to devise good regulations is usually unavailable. Periodic sampling of the commercial catch and information on the total catch and fishing effort for each major fishery or river system is vital to good fisheries management. Most provinces now restrict the number of licenses issued to fish eels, limit the quantities of fishing gear available to each license, and require the completion of a logbook to record catch and fishing effort. The regulations governing the fishing season and types of gear permitted vary between provinces. Each has a minimum size limit of 20 cm although several provinces have recently increased the minimum size limit. Catch quotas are uncommon.

Concerns about declining eel catches in many areas have led to efforts to develop a coordinated eel management plan at national and international levels. International agreement on a basic management plan is necessary because of the eel's unique biology – all eels in North America form one genetic population. The eel's complex life cycle contributes to the difficulties of effective fishery regulation. For example, there is no known relationship between the size of the adult stock of a river and the future return of elvers; the annual rate of return of elvers varies greatly between years and may be influenced most by environmental conditions at sea;

adult growth rates vary geographically within river systems and between years; the factors determining the onset of maturation are unclear; the determination of age is prone to uncertainty and eels are comparatively difficult to sex. Mathematical models of fish populations have proved useful for many fish species but have, so far, been less successfully applied to eel populations for the reasons just given. Fishing yellow eels reduces the production of silver eels from a river and fishing both stages further reduces the contribution by that river to the spawning stock. The elver fishery only occurs on rivers where no fisheries occur for larger eels. An important goal of fishery management is to find the proper balance among fisheries that exploit different eel life stages. Clearly, much work remains to be done before all of the mysteries associated with the eel have been resolved.

The worldwide demand for eels is greater than can be supplied by natural means and eel culture has become a major source of marketable eels. Eel farming is widespread in Japan, Taiwan and China and, to a lesser extent, in Holland, France and Italy. Several attempts have been made in Canada but few have been successful over the longer term, mainly due to variable market conditions. There is hope that the future will bring success.

*Underwater World factsheets are brief illustrated accounts of fisheries resources and marine phenomena prepared for public information and education. They describe the life history, geographic distribution, utilization and population status of fish, shellfish and other living marine resources, and/or the nature, origin and impact of marine processes and phenomena.*

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## *Text:*

B.M. Jessop
Biological Science Branch
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
B2Y 4A2

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